City of Houston

Vibration Analysis

In Drinking Water Operations there isn't a lot of room for error. The South East Water Purification Plant is responsible for 160 Million Gallons of Water per Day. Houston has one of the largest water purification plants in the United States. With this large amount of production there is a high risk for parts and equipments to fail. So to prevent excess breakdowns of equipment and a decline in production cause of failed parts, the City Of Houston has come up with a Plant Predictive Maintenance Shutdown Schedule. Predictive Maintenance techniques help determines the condition of in-service equipment in order to predict when maintenance should be performed. This approach offers cost savings over routine or time-based preventive maintenance because tasks are performed only when warranted.

One of the main methods that are used for predictive maintenance is Vibration Analysis. Vibration refers to mechanical oscillations about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random such as the movement of a tire on a gravel road. Vibration analysis, properly done, allows the user to evaluate the condition of equipment and avoid failures. Maintenance personnel can minimize unplanned downtime by scheduling needed repairs during normal maintenance shutdowns.

Vibration Monitoring is a critical component of any sound Predictive Maintenance (PdM) Strategy. Traditionally, data from the vibration sensors is recorded and analyzed using hand-held, walk-around vibration analyzers, or via expensive and elaborate online analysis systems. For an extremely large operations and/or very expensive equipment, these approaches represent cost effective PdM and have repeatedly shown to save money. In many applications, however, neither of these approaches is cost effective. In recent years we have seen an increased use of 4-20 mA Loop Powered sensors in the market. These sensors have proven extremely valuable, since they can be tied directly into the existing PLC/DCS Networks and do not require the skilled analyst or the expensive systems. However, these sensors only provide trending information to identify that a potential problem exists, and do not provide the detailed information necessary to determine what the cause of the problem. A hybrid approach to vibration monitoring provides the best of both worlds to establish a PdM strategy that is not only extremely cost effective but also simple to deploy.

One of the components that vibration analysis is used on is bearings and shafts. When dealing with bearings there are three major types of tools for finding bearing defects using vibration techniques such as: Vibration pen, Shock Pulse Measurement (SPM) and, Vibration Analyzer.

Vibration pen often measures the average vibration level, measured in in/sec (mm/sec). It also measures the overall vibration for early warning of machinery problems like mechanical, soft foundation, rotor box, resonance, eccentricity and more.

Shock Pulse Measurement is a signal processing technique used to measure metal impact and rolling noise such as those found in rolling element bearings and gears. Consider that you have a metal ball that hits a metal bar. At the moment of impact, a pressure wave spreads through the material of both bodies. The pressure wave quickly dampens out. The pressure wave that first goes through the materials (before it starts to vibrate) is called a "shock pulse". While the initial Shock Pulse subdues, the materials start to vibrate, this vibration wave that is measures by vibration analysis.

In the past, vibration analysis required dialing an instrument through the full spectrum to identify frequencies at which vibration was prominent. The operator then compared the peak frequencies with the operating speed and consulted a chart for likely causes. One advantage of that method was that the operator gradually developed a sense of how equipment vibrates and why certain problems occur at the same multiples of the rotating speed. The latest generation of vibration analyzers has more capabilities and automated functions than their predecessors had. Many units display the full vibration spectrum of three axes simultaneously providing a snapshot of what is going on with a particular machine. But despite such capabilities, not even the most sophisticated equipment successfully predicts developing problems.

The two components that I would like to focus on that utilizes vibration analysis are Flocculator Bearings and Shaft Monitoring. The flocculation process consists of chemical mixing, coagulation, flocculation and sedimentation which remove suspended and dissolved materials from the water. First, the chemicals are mixed with water in a rapid mixer. Then the chemicals will cause particles in the water to clot together and form floc. Then, the water passes into a tank where mixers slowly agitate the water. This process, flocculation causes the floc to form larger particles that will settle more readily. After the floc is formed, the water flows into sedimentation basin. This basin brings the water to a quite state, providing detention time of at least six hours to allow the floc to settle. The settled floc, called sludge, is removed from the basin periodically. Sludge blanket clarifiers mix and flocculate and settle in the same unit. The flow then rises through the sludge blanket encouraging filtering and settling.

In order to perform vibration analysis on the flocculator bearing and shaft, the equipment does not have to be shutdown. In fact it is preferred that the equipment be in full use. Even new or geometrically perfect bearings may generate vibration due to contact forces, which exist between the various components of bearings. Antifriction Bearing defects may be categorized as localized and distributed. The localized defects include cracks, pits and spalls caused by fatigue on rolling surfaces. The other category distributed defects include surface roughness, waviness, and misaligned races and off size rolling elements. These defects may result from manufacturing error and abrasive wear. Hence, study of vibrations generated by these defects is important for quality inspection as well as for condition monitoring. Antifriction bearing failures result in serious problems, mainly in places where machines are rotating at constant and high speeds. In order to prevent any catastrophic consequences caused by a bearing failure, bearing condition monitoring techniques, such As, temperature monitoring, wear debris analysis, oil analysis, vibration analysis and acoustic emission analysis have been developed to identify existence of flaws in running bearings. Among them vibration analysis is most commonly accepted technique due to its ease of application.

Vibration signature monitoring and analysis in one of the main techniques used to predict and diagnose various defects in antifriction bearings. Vibration signature analysis provides early information about progressing malfunctions and forms the basic reference signature or base line signature for future monitoring purpose. Defective rolling elements in antifriction bearings generate vibration frequencies at rotational speed of each bearing component and rotational frequencies are related to the motion of rolling elements, cage and races. Initiation and progression of flaws on antifriction bearing generate specific and predictable characteristic of vibration. Components flaws (inner race, outer race and rolling elements) generate a specific defect frequencies calculated from equations, mentioned by Chaudhary and Tandon. The time domain and frequency domain analyses are widely accepted for detecting malfunctions in bearings. The frequency domain spectrum is more useful since it also identifies the exact nature of defect in the bearings. Spike energy analysis makes use of spike energy meter to measure three parameters of high frequency pulses, namely, pulse amplified, pulse rate and high frequency 'random vibratory energy' associated with bearing defects. These three parameters are electrically combined into a single quantity called 'gse'.

In conclusion, Vibration Analysis has been proven to be very affective as well as cost effective. Which are two major contributions that are extremely vital when it comes to predictive maintenance in Drinking Water Operations. There are several different methods and version of Vibration Analysis that are all important contributors to predictive maintenance. Drinking Water thrives off of quality as well as quantity so there is definitely no room for failed equipment that could potentially disrupt either of those tasks.

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